Proposed Abstract for SPIE Meeting

Advanced Computed Tomography Inspection System (ACTIS): An Overview of the Technology and its Applications

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The Advanced Computed Tomography Inspection System (ACTIS) was developed by the Marshall Space Flight Center (MSFC) to meet specifications for an inspection system capable of supporting in-house solid propulsion test programs. ACTIS was designed with superior flexibility to accommodate a wide variety of test objects. This capability has made ACTIS a very popular and heavily utilized system, with projects originating from the aerospace community as well as from various other industrial concerns. In cooperation with the Technology Utilization office at MSFC, ACTIS has been applied to inspection problems in commercial aerospace, lumber, automotive, and nuclear waste disposal industries. ACTIS has also been used to inspect items of historical interest, such as time capsules.

ACTIS has consistently produced valuable results in providing information that is unattainable through conventional nondestructive inspection techniques. The ACTIS technology is currently applied to private aerospace projects by Boeing Aerospace Company. Smaller systems based on ACTIS technology are being developed and installed at various locations. One such system, the ACTIS + upgrade to existing real-time radiography (RTR) systems, has been installed at MSFC and is currently used for high-resolution imaging of small composite components. This technology has much to offer the small business and industry community, particularly in the field of identifying design and process problems in the early phases of product development to prevent defects.

In addition to NASA programs, ACTIS has benefitted many military programs. It has been used to inspect thermal batteries for Air Force systems, artillery storage canisters for Army depots, and housings for Navy cruise missiles. Most of these agencies have special-purpose CT systems of their own.

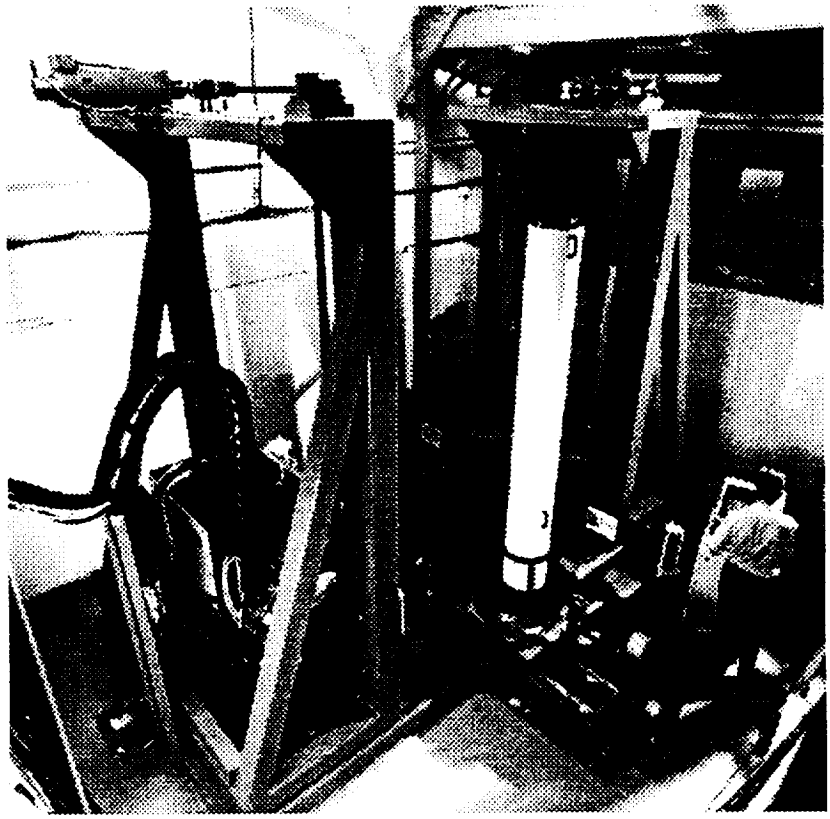

Figure 3: ACTIS Mechanical Gantry with 13 degrees of freedom accommodates objects ranging in diameter from 4" to 4' and weighing up to 2000 pounds.

One of the most unique applications of ACTIS was the inspection of a 100-year-old time capsule for *National Geographic* magazine. The time capsule, commemorating the centennial of the inauguration of George Washington, had been sealed in 1889. Before the box was opened, NASA had the opportunity to scan the contents with ACTIS. Originally, ACTIS was intended to identify how the box was assembled, and to offer suggestions on how to open it without damaging the contents. ACTIS far exceeded our expectations, providing not only information about the construction of the box (wood sandwiched between two layers of tin), but details pictures of the contents. When scanning was complete, NASA had tentatively identified five medallions, the letters on a calendar, and several books. Our findings were later verified through image enhancement performed at Technical and Analytic Sciences Corporation.

ACTIS was used to perform feasibility studies for applications of CT in the lumber industry. These studies revealed that CT provides useful information to the lumber mills, allowing them to grade lumber, optimize cutting plans to maximize yield, and cut costs by identifying scrap prior to finishing.

ACTIS has been used by the U. S. Department of Energy to inspect barrels of stored nuclear waste. The system can identify free liquids trapped within the waste and structural flaws in the barrels themselves, two significant hazards in nuclear waste storage. Using ACTIS, scientists are able to identify barrels which present an unacceptable risk, and take preventative action. ACTIS was also used by the DOE to identify the contents of waste barrels. To test these capabilities of ACTIS, the DOE provided a 55-gallon drum of simulated nuclear waste. In the barrel were several common objects: rubber o-rings, a pen, a filament, a comb, a lead-lined rubber glove, and others. ACTIS operated blind. That is, the operators were not told anything at all about the contents of the barrel. The tests produced some impressive results. ACTIS was able to image the face on a dime contained in the 55-gallon drum of waste.

Various automotive manufacturers have explored the use of ACTIS in designing new products. The system has been used to inspect prototype steering wheels, engine blocks, gear boxes, and other structures for automotive applications. ACTIS has become an integral part of prototype development for some of these companies. American automotive manufacturers use CT data to evaluate performance of new designs and processes early in the development cycle to reduce the potential for defects in routine production.

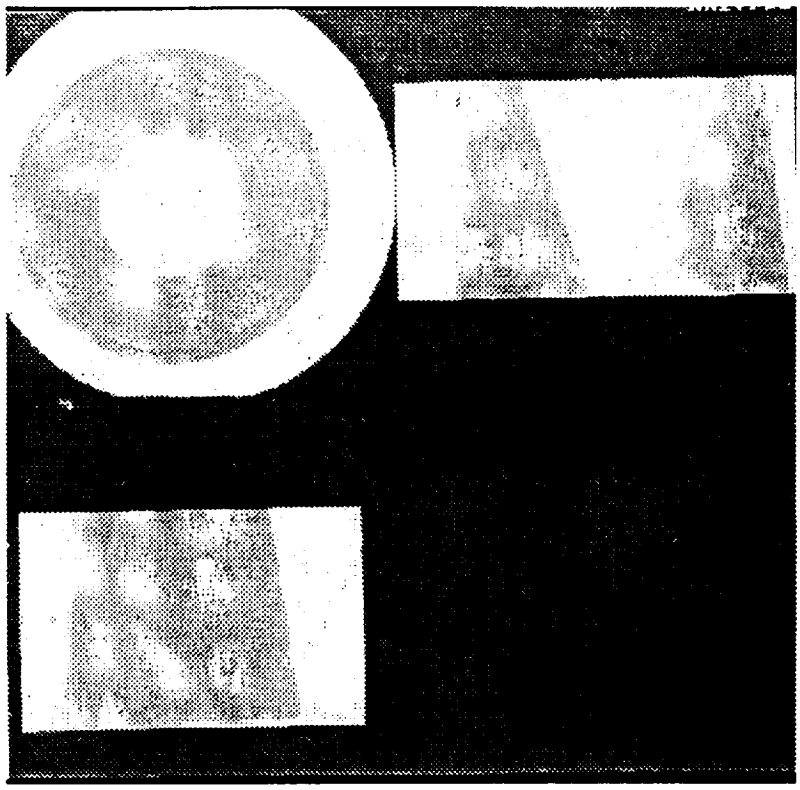

Figure 4: Multi-planar Reconstruction of a Rocket Nozzle Exit Cone clearly represents the location of defects.

ACTIS systems are now sold as off-the-shelf items. Unfortunately, these systems are too expensive for most small businesses to afford. However, there are several alternatives for small businesses and industries interested in applying ACTIS technology. First, various CT system manufacturers can tailor a system for a specific need at substantially reduced cost. NASA recently purchased an ACTIS-II system, a much smaller and somewhat modified version of ACTIS, at about 5% of the cost of the original system. Interested businesses can often lease large industrial scanners for a few days at a time. Several large industrial scanners are available for lease. If the program is well-planned, this can be a cost-effective way to use ACTIS technology. Finally, if the object under test is small and portable, small businesses can buy CT services at a medical radiology laboratory. NASA did all its early work with CT using a local hospital after-hours. For certain materials, the medical systems actually perform superior to industrial ones.

CONCLUSIONS:

ACTIS is a versatile inspection tool which has proven useful in addressing many of the problems associated with inspecting complex objects, not only in the government aerospace industry, but other industries as well. NASA has applied this technology to the problems of material science for propulsion systems. A variety of other industries have benefitted from ACTIS technology. ACTIS results are superior to conventional inspection techniques in flexibility, contrast sensitivity, spatial resolution, and visualization. CT inspection typically imposes fewer restrictions on the geometric and other physical features of the object under test. Although CT systems are quite expensive, the results they provide are useful, especially early in the development of new products, by allowing engineers to detect basic design flaws and process anomalies early enough to eliminate them. Small business can take advantage of ACTIS technology in a number of ways: buying a smaller system, leasing and industrial system, or buying time

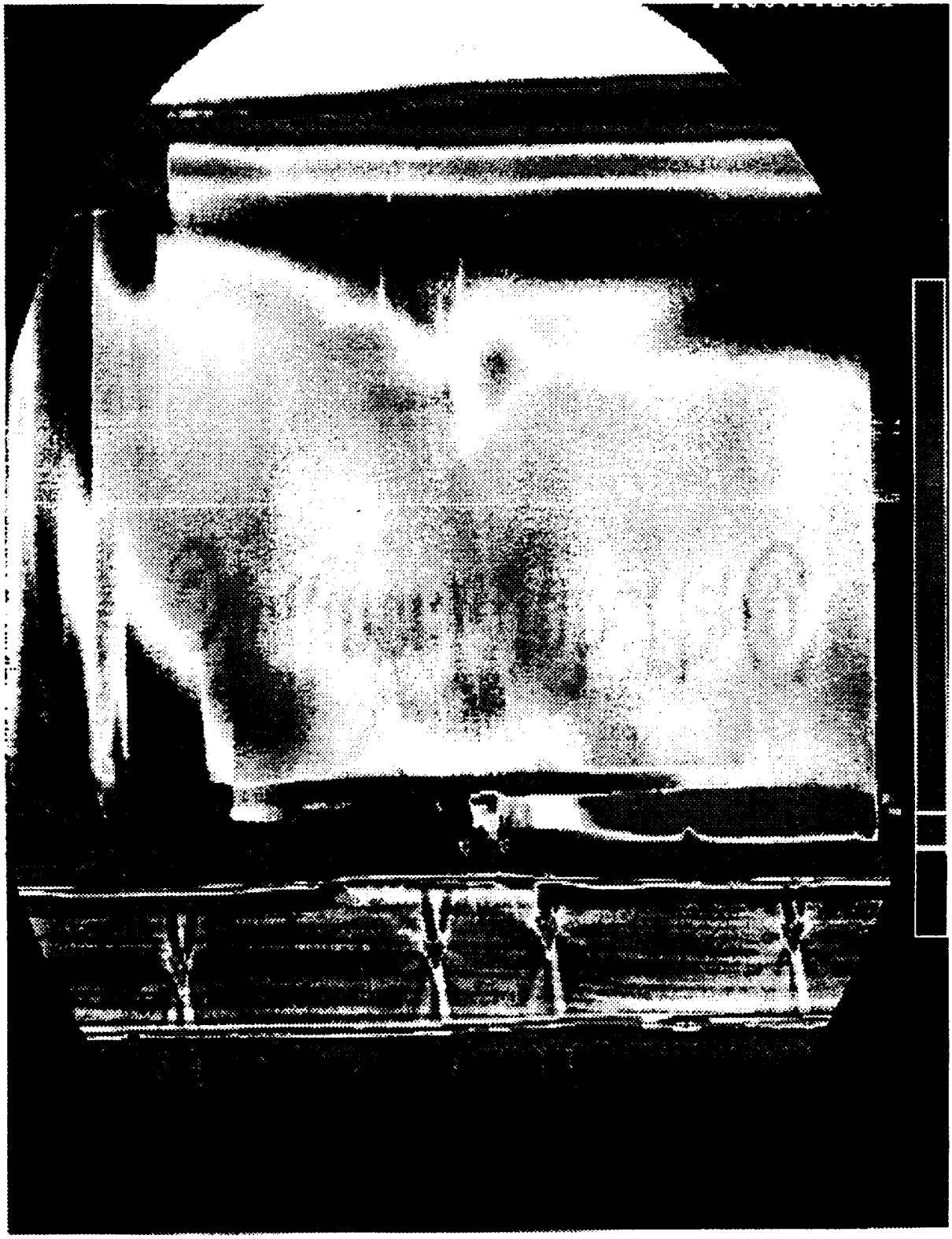

Figure 5: Unenhanced image from time capsule. Note the faint letters spelling out "Stettiner-Lambert & Co." These letters turned out to be written on a calendar inside the capsule.

on a medical system. Although ACTIS is not the answer to all inspection problems, it provides small business and industry with an excellent tool for building quality into its products.

Figure 6: Image of time capsule lid. Utility of ACTIS for lumber industry was discovered here. Note the grain of the wood is visible, as well as separations between planks, and nail locations.